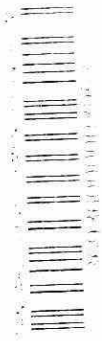

AIR QUALITY

NORTHWESTERN ONTARIO

Annual Report, 1984

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ONTARIO MINISTRY OF THE ENVIRONMENT

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TABLE OF CONTENTS

SUMMARY

This report presents results of the Ministry's air quality assessment program in northwestern Ontario for 1984. It includes data from 10 communities where long-term monitoring is conducted, plus summaries of special studies in the Thunder Bay area.

ATIKOKAN

Pre-operational sampling was carried out for a third year around Ontario Hydro's power plant at Atikokan. Residual arsenic and iron contamination was again found in vegetation and soil around formerly active iron ore mines.

Suspended particulate matter, monitored at the Atikokan Weather Station, continued to be recorded at satisfactory levels.

BALMERTOWN

Arsenic persisted at elevated concentrations in vegetation on company property near two gold mines, but was near normal in the adjoining townsite. Except for one sample with slightly elevated arsenic, both arsenic and mercury met guidelines in all vegetable samples from residential gardens.

In 1984, there were 50 sulphur dioxide readings above the maximum acceptable limit, down from 104 such occurrences in 1982, and 65 in 1983. There were no visible symptoms of vegetation damage, either on or off company property. This improvement is at least partly attributed to a voluntary sulphur dioxide emission reduction program implemented by Campbell Red Lake Mines Limited.

DRYDEN

Airborne chloride and sodium were elevated on company property around a new secondary treatment system (lagoon) operated by Great Lakes Forest Products Limited. Further intensive monitoring near the lagoon is being carried out in 1985.

Odour levels caused by total reduced sulphur (TRS) declined in the town centre in 1984, continuing the trend started in 1982. This improvement was mainly due to better controls on odour emissions from the mill.

FORT FRANCES

For the first time since the Fort Frances kraft pulp mill was constructed in 1971, there was no new vegetation injury recorded in the surrounding area.

Levels of dustfall and suspended particulate matter were about the same as preceding years. Emissions of wood fines and saltcake from mill operations sometimes contributed significantly to dustfall readings above the provincial objective.

TRS concentrations declined in 1984 at two sites, but increased at a third location. The provincial guideline was frequently exceeded at all sites.

The company and the Ministry will closely monitor mill operations to minimize upset conditions which could lead to excessive odour and particulate emissions.

KENORA

No vegetation damage complaints were received in 1984. Dustfall was generally acceptable at three of the four monitoring sites.

LONGLAC

Although there were some moderately elevated dustfall readings, the data did not indicate a significant fallout problem from two local wood waste burners. Suspended particulate levels were normal.

MARATHON

Average airborne sulphur levels have shown little change during recent years. Concentrations of reduced sulphur exceeded

the provinical guideline on 22 occasions at the Ministry's monitoring station in the townsite. A modernization program at the local pulp mill is expected to result in decreased emissions of reduced sulphur during the next two or three years.

RED ROCK

Because of fallout from the bark-burning boiler at the Domtar mill, dustfall in the townsite increased from 1983 to 1984. A new Control Order to deal with this problem and with other issues is currently being negotiated.

Odour levels declined from 1983 to 1984, with only 23 exceedances of the TRS guideline. Further emission controls to be implemented in 1985 should result in full compliance with the guideline.

TERRACE BAY

Reduced sulphur was above the Ontario guideline in Terrace Bay for 38 hours in 1984 because of emissions from the Kimberly-Clark kraft pulp mill. The company is invesitgating options to reduce its emissions of total reduced sulphur. Compliance with the guideline will be a requirement in the next Control Order, due in 1987.

THUNDER BAY

Average dustfall in Thunder Bay in 1984 was within the acceptable range and has been essentially unchanged for several years. The elevated readings sometimes recorded at two sites in the Westfort area were caused by flyash emissions from Great Lakes Forest Products Limited.

Average suspended particulate matter in the air was satisfactory during the year. About 95 percent of the samples met the 24-hour Ontario air quality objective. Soiling index levels were also acceptable.

With the exception of three hours at one site, full compliance was achieved for all air quality objectives for sulphur dioxide. Total reduced sulphur (TRS) levels near Great Lakes Forest Products Limited were also acceptable during the part of the year for which data were available.

Ozone, a pollutant usually associated with long-range transport, met the Ontario air quality objective at all times.

INTRODUCTION

PURPOSE OF MONITORING PROGRAM

The Ontario Ministry of the Environment conducts an air quality assessment program throughout the province. This program monitors, in outdoor air, the levels of pollutants that may adversely affect human health, animal life, vegetation, and the use and enjoyment of property. These surveys record compliance with air quality objectives, evaluate the need for and results of pollution controls, and determine long-term trends in air quality.

In northwestern Ontario, air quality surveys first began in 1963 to measure airborne dust in the City of Thunder Bay. By 1984, the program had expanded to include eight pollutants, monitored by more than 90 instruments in 10 urban centres. Ontario Hydro also has air quality networks in Thunder Bay and Atikokan. Data from air quality instruments are supplemented by vegetation, soil and snow sampling studies, and by predictions of pollutant levels with mathematical models.

Monitoring in the region is mostly conducted in urban areas and near industrial sources of air pollution (eg. mining, pulp and paper). Therefore, air quality problems described in this report are not typical of the region, where air quality is generally excellent.

Acid rain is a major environmental issue in eastern North America and parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study, is assessing the effects of acid fallout and is developing possible answers to this problem. The Ministry's Northwestern Region participates in this program through precipitation sampling surveys and research on the aquatic and terrestrial effects of acid rain. The findings of these studies are reported elsewhere.

A major new development in the air quality program in northwestern Ontario is the installation of a telemetry system to improve the quality of data and the speed with which it is

received. This system is expected to be in place by early 1986 and will permit the Ministry to obtain immediate readings from any continuous monitor in the region.

POLLUTANTS AND THEIR MEASUREMENT

Under this heading, only those contaminants routinely monitored in northwestern Ontario will be considered. Carbon monoxide and hydrocarbons are not presently measured, nor are exotic organic compounds. If the need arises, many of the more unusual pollutants can be monitored with mobile equipment from the Ministry's Air Resources Branch, Toronto.

Particulate Matter

There are many man-made and natural sources of particulate matter. Typical man-made sources in northwestern Ontario are forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Particulate matter may also be emitted from forest fires, volcanoes, and dust storms. Depending on particle size and chemical makeup, particulate matter may be harmful to health and vegetation, may adversely affect visibility, and may cause local nuisance problems. In Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), or soiling index.

Dustfall is particulate matter that settles out from the air by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed (1). The monthly air quality objective (maximum acceptable limit) for dustfall is 7 $g/m^2/30$ d (grams per square metre during 30 days). The annual objective is 4.6 $g/m^2/30$ d. Dustfall provides an estimate of fallout of particulate matter from local sources, including dust from nearby construction or from vehicular traffic.

Suspended particulate matter comprises particles of small size which remain entrained in the air for long periods. This

material may come from local or distant sources. It is measured with a high-volume sampler for a 24-hour period every sixth day (2). The difference in the weight of a fibreglass filter before and after exposure determines the quantity of particulate matter collected. The air quality objective is 120 $\mu g/m^3$ (micrograms per cubic metre of air) averaged over 24 hours, or 60 $\mu g/m^3$, annual geometric mean.

Soiling index is a measure of the soiling or darkening properties of very small airborne particles and is expressed as coefficient of haze (COH). It is probably closely related to the concentration of respirable particulate matter. A measured volume of air passes through a paper tape which moves through an automated sampling unit to produce a reading every hour. The reduction of light transmitted through the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled. The Ontario objective is 1.0 COH, 24-hour average, and 0.5 COH, annual average.

Gaseous Pollutants

Sulphur Dioxide

Sulphur dioxide (SO_2) is one of the world's major atmospheric pollutants and has many well-known adverse effects on human health, vegetation and property. It is also one of the main contributors to the formation of acid rain. In northwestern Ontario, the principal SO_2 sources are small compared to those in some other parts of the province. The main regional emitters of SO_2 are, in approximate descending order of importance, the Ontario Hydro generating station in Thunder Bay, sulphite pulp mills, gold ore roasting, and industrial boilers. SO_2 is measured with passive samplers (sulphation plates) to provide a semi-quantitive estimate of the presence of sulphur-containing gases. Results are expressed as monthly sulphation rates, in mg $SO_3/100\ cm^2/d$ (milligrams of sulphur trioxide per 100 square centimetres of treated filter paper per day). Sulphur dioxide is also monitored with continuous analyzers (3). There are three

air quality objectives for this pollutant: 0.25 ppm (parts of sulphur dioxide per million parts of air, by volume), hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

Total Reduced Sulphur

Total reduced sulphur (TRS) comprises a group of sulphur-containing gases found in emissions from kraft pulp mills, which are the sole significant TRS source in the region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary respiratory irritation or may injure vegetation. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air, by volume), averaged over one hour, is used as an air quality objective near kraft pulp mills. TRS may be measured with sulphation plates, for semi-quantitative results, or with continuous analyzers (4). In northwestern Ontario during the past few years, the Ministry has phased out an older type of TRS monitor. These instruments have not been manufactured for several years. Also, parts are now very costly and the instruments require a large amount of technician time to be operated successfully. However, while overcoming many of the problems with the older type of monitor, the new one has the drawback of a lower response to TRS compounds. This shortcoming results in readings which are too low. Modifications to these instruments to improve their efficiency are planned in the near future.

Ozone

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a secondary product of reactions between nitrogen oxides and hydrocarbons. If it is present at high concentrations, it may adversely affect health and vegetation. Since ozone-forming compounds are not emitted in large amounts in northwestern Ontario, elevated ozone readings, if present, would suggest long-range transport from outside the region. Ozone is measured with continuous analyzers (5), and the current air quality objective is 0.08 ppm, averaged over one hour.

Nitrogen Oxides

Nitric oxide (NO) and nitrogen dioxide (NO_2) are together termed nitrogen oxides (NO_x). Both may be emitted from natural and man-made sources. High-temperature fuel combustion, which occurs in vehicle engines and thermal power plants, is the main man-made emission source. At concentrations measured in ambient air, NO has no known adverse effects. NO may, however, oxidize to NO_2 which, in turn, may affect health and visibility. Both compounds also enter into photochemical reactions with ozone and other oxidants, and contribute to the formation of acid rain. Nitrogen oxides are monitored with continuous analyzers (6). The air quality objectives for NO_2 are 0.2 ppm, 1-hour average, and 0.1 ppm, daily average.

Miscellaneous

The occurrence and effects of some of the foregoing pollutants, as well as others, are also assessed by vegetation injury and by contaminant levels in vegetation, soil and snow. Standard Ministry procedures (7, 8, 9) are followed in collecting and analysing these types of samples. Arsenic, chloride, fluoride (10), sulphur and heavy metals are typical pollutants examined this way. Their levels in a study area are compared with normal background levels at sites unaffected by pollution. In 1984, the Ministry developed proposed contaminant guidelines for vegetation, soil and snow. These guidelines are used in this report. Their exceedance suggests that contamination is present, but does not necessarily imply adverse effects.

Dustfall, sulphation, and suspended particulate matter determinations, as well as most analyses for vegetation, soil and snow, are carried out at the Ministry's Thunder Bay laboratory. Metals, nitrate, and sulphate in suspended particulate matter, and sulphur and halides (chloride, fluoride) in vegetation and soil, are analysed at the Ministry's Toronto laboratory. The Toronto laboratory also provides a service for the determination of unusual contaminants (e.g.: organic compounds such as PCBs or pesticides).

The Ministry's Air Resources Branch processes the strip charts from continuous analyzers, and produces computer printouts of all air quality data for the region. The Thunder Bay regional office has developed computer programs to improve access to air quality and meteorological data in Toronto.

RESULTS AND DISCUSSION

ATIKOKAN

Ontario Hydro Generating Station

In 1981, the Ministry and Ontario Hydro began an environmental monitoring program around a lignite-fired generating station under construction near Atikokan. In the air quality part of this program, Ontario Hydro operates the air quality monitoring network and the Ministry collects precipitation, vegetation, soil, and snow samples (Figure 1). By 1985, when the 200-megawatt plant is completed, at least three years of background data will have been collected.

Consultants for Ontario Hydro submit quarterly and annual air quality reports, and the Ministry prepares annual reports on terrestrial studies. The Ministry reports for 1981, 1982, and 1983 confirmed the presence of residual arsenic and iron contamination in vegetation and soil near the power plant. The source of these contaminants was emissions from nearby iron ore pelletizing plants which operated from the mid-1970's to about 1980 (11). The Ministry and Ontario Hydro plan to continue their monitoring programs for several years after the generating station is commissioned to ensure compliance with environmental regulations.

Particulate Matter

At the Ministry's monitoring site in the Town of Atikokan, all 56 samples of TSP complied with the 24-hour air quality objective of 120 $\mu g/m^3$. The annual geometric mean of 23 $\mu g/m^3$ was also well below the maximum acceptable limit of 60 $\mu g/m^3$.

BALMERTOWN

The Ministry has conducted air quality surveys near two gold mines in Balmertown since 1971. For many years, Campbell Red Lake Mines Limited, and the Dickenson-Sullivan Joint Venture, Arthur W. White Mine (formerly Dickenson Mines Limited), emitted significant amounts of airborne arsenic trioxide and sulphur dioxide from ore roaster stacks. In the mid-1970's, both mines reduced arsenic emissions by more than 95%. In early 1980, Dickenson changed its ore processing methods and shut down its roaster.

Arsenic

In 1984, arsenic concentrations in leaves of trembling aspen trees at 17 sites near the mines (Figure 2) remained elevated on company property but were near normal levels in the townsite (Figure 3). A snow sampling survey in January showed a similar pattern of contamination. Arsenic in vegetation on company property has declined from 1982 to 1984. The elevated arsenic near Campbell's ore roaster is attributed to fugitive emissions during roaster start-up or shutdown, or to emissions when trucks are loaded with arsenic waste from the roaster baghouse. Table 1 compares arsenic readings for the past 12 years at selected sites on and off company property. Table 2 presents 12 years of data from planted roadside trees in the townsite. Both tables show that average arsenic concentrations in vegetation in 1984 were the lowest recorded since monitoring began in 1972.

Except for lettuce, arsenic in garden vegetables was again well below the former limit (10 µg/g, dry weight) specified by the Health Protection Branch, Canada Department of Health and Welfare (Table 3). The elevated arsenic in lettuce was attributed to inadequate washing of samples prior to analysis. Because arsenic in garden soil remains high, residents are advised to thoroughly wash vegetables from Balmertown gardens.

Mercury

Because mercury has been used in ore processing at the mines, the Ministry has regularly examined mercury concentrations in local vegetation, soil and snow. The 1984 data show that mercury was moderately elevated in vegetation and snow close to the mines, but was normal in the townsite. All samples of vegetables from residential gardens met the recommended international guideline for mercury (0.5 µg/g, dry weight). Campbell Red Lake discontinued the use of mercury in ore processing in November, 1982, but it is still part of the process at Dickenson.

Sulphur Dioxide

Sulphur dioxide (SO_2) sometimes exceeds desirable levels in Balmertown. In 1984, the Ministry's Balmertown monitor recorded 50 hourly SO_2 readings and two, 24-hour averages which exceeded acceptable levels. The maximum hourly average was 0.63 ppm, about twice the Ontario objective. The annual average (0.005 ppm) was satisfactory. No confirmed SO_2 injury to vegetation was found in 1984 in the townsite or on company property.

The number of exceedences of the 1-hour SO_2 objective declined from 104 occurrences in 1982, to 65 in 1983, and 50 in 1984. Similarly, the annual average concentration decreased from 0.013 ppm in 1982, to 0.008 ppm in 1983, and 0.005 ppm in 1984. During the growing season (May to September), SO_2 was above the acceptable hourly limit 21 times. Fortunately, most of these incidents were at night, when vegetation is usually less sensitive to SO_2 injury than during the day. Campbell Red Lake Mines operates a voluntary emission reduction program, the intent of which is to suspend ore roasting when the wind carries roaster-stack emissions over the townsite during the growing season. The company submits quarterly reports to the Ministry on roaster shutdowns due to this SO_2 abatement program.

DRYDEN

For several years, the Ministry has monitored air quality near a bleached kraft pulp mill and adjacent chlor-alkali plant in Dryden. Our earliest surveys showed that mercury, particulate matter and offensive odours around the mill were often well above desirable levels. Abatement action and process changes in the 1970's successfully controlled the discharge of mercury and particulate matter. Mill modernization in the early 1980's reduced emissions of odour-causing TRS. In 1984, the Ministry continued to monitor odour levels, and conducted a moss exposure study around the mill's new secondary treatment system.

Lagoon

A new secondary treatment system (lagoon) was completed in late 1983 to process liquid waste from the Dryden mill. A moss exposure experiment was conducted in the summers of 1983 and 1984 to assess conditions before and after the lagoon began operating. This study showed that chloride and sodium levels in moss were significantly higher in 1984 than in 1983 at some locations on company property. Off-property levels were similar in the two years.

Because of continuing public concerns about possible health effects from foam, spray drift, and odours from the lagoon, the Ministry carried out extensive air sampling in 1985. The company has taken abatement action to control foam on the lagoon, and the Medical Officer of Health is monitoring health concerns in the area (12).

Kraft Mill

Odour Levels

Offensive odours caused by reduced sulphur compounds are monitored in Dryden with a continuous total reduced sulphur (TRS) analyzer. Figure 4 shows the monitoring sites. For technical reasons, the instrument was relocated from station 61026 to 61027 in May. As Table 4 shows, air quality in the town centre continued the trend of improvement shown in recent years. The

annual average TRS concentration (1.1 ppb), and the number of hours of TRS above the provincial guideline were the lowest yet recorded. The 1984 decline is probably a result of reduced emissions from the modernized mill. However, some of the "improvement" may reflect a less sensitive response to TRS by the new instrument installed at station 61027 in May.

FORT FRANCES

During its first few years of operation, emissions from a bleached kraft pulp mill in Fort Frances resulted in excessive fallout of particulate matter, high concentrations of malodorous gases, vegetation damage, and complaints from nearby residents. In recent years, some emission reductions were achieved and, in 1980, a Control Order was issued to obtain compliance with Ministry regulations. A "buffer zone" was also created through purchase of residential land adjacent to the mill.

Air quality studies in Fort Frances have been conducted regularly since 1972 near the Canadian mill, and since 1974 near a similar plant owned by the same company on the U. S. side of the border (Figure 5).

Vegetation Effects

For the first time since the mill started production in 1971, no new vegetation injury was found near the Fort Frances mill, either on or off company property. There was the usual occurrence of insect damage to trees. Also, there was a localized outbreak of a fungus disease ("anthracnose") on foliage of several kinds of trees and shrubs near Victoria Avenue and Sinclair Street, and on Manitoba maple and bur oak trees near Mowat Avenue and Church Street. Chloride and sodium in foliage of Manitoba maple from 18 sites (Figure 5) were elevated in, and immediately adjacent to, the buffer zone (Table 5). Chloride levels have dropped in recent years, but sodium has been very variable. No visible vegetation injury was found off company

property around the aeration lagoons at the secondary treatment system on Eighth Street (Figure 6).

Particulate Matter

Dustfall results for 1984 are summarized in Table 6. Except at the two monitoring sites farthest from the pulp mill (stations 62032 and 62037), the annual air quality objective was not met. Wood fibres often accounted for the largest fraction (up to 50 percent) of total dustfall at monitoring sites just outside the boundaries of the mill's buffer zone. Road dust, fly ash, and insect parts were also sometimes present in significant amounts. A comparison of average dustfall over the past six years (Table 7) shows little change from 1979 to 1984. Saltcake levels, which had dropped after 1979, rose again in 1984. Saltcake (sodium sulphate) is a particulate contaminant commonly emitted from kraft pulp mills. Snow samples collected in early 1984 confirmed the dustfall results: elevated saltcake in the buffer zone and above-normal carbon and suspended solids for 200-300 metres outside the zone. Carbon and suspended solids are used as tracers of wood fines.

Total suspended particulate matter showed no significant change in 1984 compared with preceding years. The annual average at the monitoring site near the mill (station 62035) was 55 $\mu g/m^3$ and met the provincial objective. Seven daily readings exceeded the 24-hour objective. The annual average TSP at the Fort Frances cemetery (station 62032) was 32 $\mu g/m^3$, which is normal for this location and well within the Ontario objective. There was only one exceedance of the daily objective at this site.

Odour Levels

Sulphation rate averages have shown little change over the past four years. In contrast, average TRS declined at the site nearest the Fort Frances kraft mill (station 62052) and at the Fort Frances cemetery (station 62032) (Table 8). At least part

of this decrease is ascribed to the performance of a new type of TRS monitor installed at these sites in 1983. The new monitor is less sensitive to TRS than the instrument it replaced. A modification to the new monitor, expected in 1986, should restore instrument response to former levels. At station 62051, where an older type of monitor was operating, the average TRS concentration, the maximum 1-hour reading, and the number of guideline exceedances were all higher in 1984 than in 1983. TRS at stations 62052 and 62051 are influenced mostly by emissions from the Fort Frances kraft mill. Readings at station 62032 are affected mainly by discharges from the kraft mill in International Falls, Minnesota, and to a lesser degree by TRS from the Fort Frances kraft mill and from the Canadian mill's secondary treatment system (lagoon). Sulphation plate readings at the north end of Fort Frances were well above normal background, which indicated that the lagoon was a significant source of offensive odours. The Ministry conducted a special air quality study near the lagoon in 1985. Results from this study will appear in a separate report expected about the end of 1985.

KENORA

The Ministry has monitored air quality for the past 13 years near a sulphite pulp mill in Kenora. Occasional upset conditions in this plant have caused localized vegetation damage, and fallout of particulate matter emitted from the mill's power boiler stack has sometimes been a nuisance to nearby residents.

Vegetation Effects

No complaints of air pollution damage to vegetation were received in 1984. A brief survey in July confirmed that there was no sulphur dioxide injury to vegetation around the mill.

Particulate Matter

As Table 9 shows, average dustfall in Kenora in 1983 was about the same as the average for the preceding three years. Dustfall frequently exceeded the monthly objective at

station 61007. Levels at the other three sites in the four-station network (Figure 7) was usually acceptable. Flyash from the mill's boiler stacks was mainly responsible for the highest dustfall readings at station 61007. A new Control Order, which will require full compliance with Ministry regulations for particulate matter, has been served to the company .

Sulphation Rates and Sulphur Dioxide

Average sulphation rates in 1984 were the lowest recorded in recent years (Table 10). Sulphur dioxide concentrations at station 61030 met all provincial air quality objectives.

LONGLAC

Particulate Matter

To obtain data on fallout of particulate matter around two wood waste burners in Longlac, a monitoring network of five dustfall jars and one high-volume sampler was established in late 1983 (Figure 8).

Only 20 hi-vol samples were collected at station 63070 in 1984. Nineteen of these met the provincial air quality objective while one was slightly above. The dustfall data are summarized in Table 11. Several monthly readings were above desirable levels. Dustfall at two of the five sites met the annual objective. The highest value at station 63071 (11.9 $g/m^2/30$ d in June) was caused mainly by fallout of wood fibres, but the maximum reading at station 63072 (17.4 in July) was attributed to road dust, insect parts, and other biological material. The 1984 data do not indicate a serious fallout problem from the wood waste burners, but monitoring will be continued at least to the end of 1985.

MARATHON

Historically, airborne contaminants of concern at Marathon have included mercury, particulate matter, and sulphur compounds

from a bleached kraft pulp mill and adjacent chlor-alkali plant. Mercury emissions ceased when the chlor-alkali plant was closed in 1977. Fallout of particulate matter in the townsite was shown in several surveys to be negligible. At present, the Ministry maintains five air quality monitoring stations in Marathon (Figure 9) and one in Heron Bay.

Odour Levels

Table 12 shows that average sulphation levels have been stable since major mill modernization and pollution control programs were completed in 1978.

Table 13 indicates that average odour levels and maximum readings were very similar in 1983 and 1984. As noted elsewhere in this report, an increase in TRS levels may be recorded in future with improvements in the monitoring efficiency of our instruments. To alert the mill when community odour levels above the desirable limit occur, the company installed telemetry equipment at the end of 1984 to transmit TRS readings directly from our monitor to the mill. Decrease in TRS emissions are expected in future as a result of a mill modernization program currently in progress.

Sulphur Dioxide

A continuous sulphur dioxide monitor was installed at station 63034 in August, 1984. For the 109 days of data obtained during the year, all air quality objectives for sulphur dioxide were easily met.

RED ROCK

In Red Rock, the Ministry operates a small air quality monitoring network near a kraft pulp mill to measure dustfall and odour levels in the townsite. The network comprises four dustfall jars and sulphation plates at stations 63080 to 63083, and a continuous TRS analyser at station 63084 (Figure 10).

Particulate Matter

Table 14 summarizes dustfall in Red Rock for the period before (1980-82) and after (1983, 1984) a new recovery furnace was installed at the local pulp mill. The key results in the table are the decline in total dustfall and saltcake in dustfall after the new recovery furnace started up in late 1982. Total and insoluble dustfall increased from 1983 to 1984 because of fallout of wood char particles in May and June. This fallout is attributed to emissions from the mill's bark-burning power boiler. The company is investigating options to reduce these emissions.

Odour Levels

Average sulphation rates in 1984 continued the decline trend which began in late 1982 (Table 15). A similar trend is shown for TRS in Table 16. Compared with 1982, annual average TRS in 1984 decreased 74 percent, the maximum one-hour average dropped 67 percent, and the number of hours above the guideline declined 93 percent. A recent emission inventory report by the company identified emissions from the mill's brown stock washer vents as the sole cause of elevated TRS readings in the townsite. Action which is under way to control this emission source should result in compliance with the Ministry's TRS guideline.

TERRACE BAY

Previous surveys have shown that the kraft pulp mill in Terrace Bay does not cause fallout of particulate matter in the adjoining townsite. Therefore, the Ministry's monitoring program is directed toward measurement of odour levels in the townsite and at three points where an effluent ditch from the mill crosses the TransCanada Highway (Figure 11).

Odour Levels

Compared to 1982 and 1983, average sulphation rates in 1984 declined at two of the townsite monitoring locations (Table 17). None of the readings indicated a serious odour problem. The first crossing point of the effluent ditch at the highway (station 63094) had the highest average sulphation rate for the year.

TRS data (Table 18) shows that, during 1984, there were 38 hourly readings above the provincial guideline of 27 ppb at the Ministry's monitoring site in 1984. The maximum hourly average was 104 ppb. Results for 1983 were similar. To alert the mill when pollutant concentrations are above desirable levels, TRS data from the Ministry's monitor are continously telemetered to the mill. The Ministry is currently negotiating with the company to secure further abatement of TRS emissions.

THUNDER BAY

The Ministry maintains a 10-station air quality monitoring network in Thunder Bay. The locations of these sites, plus those operated by Ontario Hydro, are shown in Figure 12. Three of the Ministry's Thunder Bay monitoring stations (63005, 63022, 63040) are part of the NAPS (National Air Pollution Surveillance) network operated by Environment Canada. In addition to its network of seven sulphur dioxide monitors, Ontario Hydro has dustfall jars at nine sites on and near its Mission Island property to measure dust from flyash disposal and coal storage areas around its power plant. The following discussion reviews data from the Thunder Bay monitoring network, and includes brief summaries of some special studies carried out in the Thunder Bay area in 1982.

Particulate Matter

Dustfall

Dust emitted from grain elevators was formerly a nuisance to

Thunder Bay residents. Dustfall measurements near the elevators began in 1970, and the network has been revised periodically since then. The 1984 data for the 10 sites now monitored are summarized in Table 19. During the year, average dustfall exceeded the maximum acceptable limits at two of the 10 sites. Road dust was the main cause of the highest reading at the Main Street site (station 63019). Most of the other elevated readings occurred at station 63046 (Can-Car, Montreal Street) and at station 63047 (Totem Trailer Court). The principal contributor to dustfall at both sites was flyash. Emissions from coal-fired power boilers at Great Lakes Forest Products Limited were the source of this fallout. While some flyash deposition still occurs (Table 20), the amounts are much less since late 1983, when dust collection equipment was installed in the mill's power boilers. The Ministry and the company will be negotiating further abatement action to control these emissions.

Suspended Particulate Matter and Soiling Index

Total suspended particulate matter (TSP) was generally satisfactory throughout Thunder Bay in 1984 (Table 21). About five percent of the total samples for all six monitoring sites exceeded the 24-hour air quality objective of 120 $\mu g/m^3$. The annual objective was met at all locations. Filters from the two city-centre stations (63005 and 63022) had acceptable concentrations of heavy metals, including lead. Levels of sulphate and nitrate, due to long-range transport, varied considerably.

Soiling index levels easily met the daily and annual air quality objectives at the only site (station 63040) where these measurements are made.

Gaseous Pollutants

Sulphur Dioxide (SO_2)

The principal industrial sources of sulphur dioxide in Thunder Bay are a 310-megawatt coal-fired generating station and four pulp and paper mills. Collectively, these sources are

relatively small, and total SO_2 emissions from the city area are estimated to be less than 100 metric tons per day. The network of nine SO_2 monitors (seven belonging to Ontario Hydro and two owned by the Ministry) showed, with three exceptions, full compliance for all SO_2 air quality objectives in 1984 (Table 22). The hourly objective for SO_2 was slightly exceeded on Mt. McKay for one hour on January 22, on April 24, and on May 9. Wind data implicate Ontario Hydro as the cause of the elevated reading on May 9, and Great Lakes Forest Products Limited on the other two dates.

Total Reduced Sulphur (TRS)

At the Montreal Street monitoring site (station 63046), the TRS guideline (27 ppb) was not exceeded during the year (Table 23). The annual average was about the same as 1983. In 1984, however, monitoring was conducted for only the first half of the year because of a need to relocate the monitoring equipment. The TRS instrument used in 1983 and 1984 was also less responsive than the monitor used before and gave readings lower than true concentrations.

Ozone (O_3)

Ozone did not exceed the maximum acceptable limit (80 ppb) during 1984 at the Ministry's monitoring site (station 63040). The highest one-hour average, 58 ppb, was similar to the maximum in preceding years. Highest readings were usually associated with southerly winds. Several studies have shown that ozone is a long-range transport pollutant whose primary sources are large urban and industrial centres.

Special Studies

Pulp Mills

Surveys again showed that vegetation near the two sulphite pulp mills in Thunder Bay was free of visible symptoms of air pollution damage.

Thunder Bay Terminals Limited

A report on 1984 air quality monitoring near Thunder Bay Terminals Limited (13) showed that this coal terminal continued to operate satisfactorily. There has been no increase in dust levels at off-property monitoring sites since coal shipments began in 1978.

Acid Rain Studies, Hawkeye Lake

SENES Consultants Limited, on contract to the Ministry, is conducting a study of the terrestrial effects of acid rain in northwestern Ontario. Most of this work is being carried out in a 95-hectare watershed near Hawkeye Lake, about 40 kilometres north-northwest of Thunder Bay. At this site, sulphur dioxide, nitrogen oxides and ozone are continuously monitored. In 1984, sulphur dioxide and nitrogen oxide levels met all air quality objectives and were only occasionally above the detection limit (about 5 ppb). The maximum ozone reading was 35 ppb, well below the acceptable limit of 80 ppb. The results of other investigations at Hawkeye Lake will be reported separately.

ACKNOWLEDGEMENTS

The assistance of staff of the following agencies is gratefully acknowledged: Atmospheric Environment Service, Atikokan Weather Station, for operating a high-volume sampler; Dingwall Medical Clinic, Dryden, for assistance in operating our TRS monitor; and Ontario Hydro for data from its SO_2 monitoring network in Thunder Bay.

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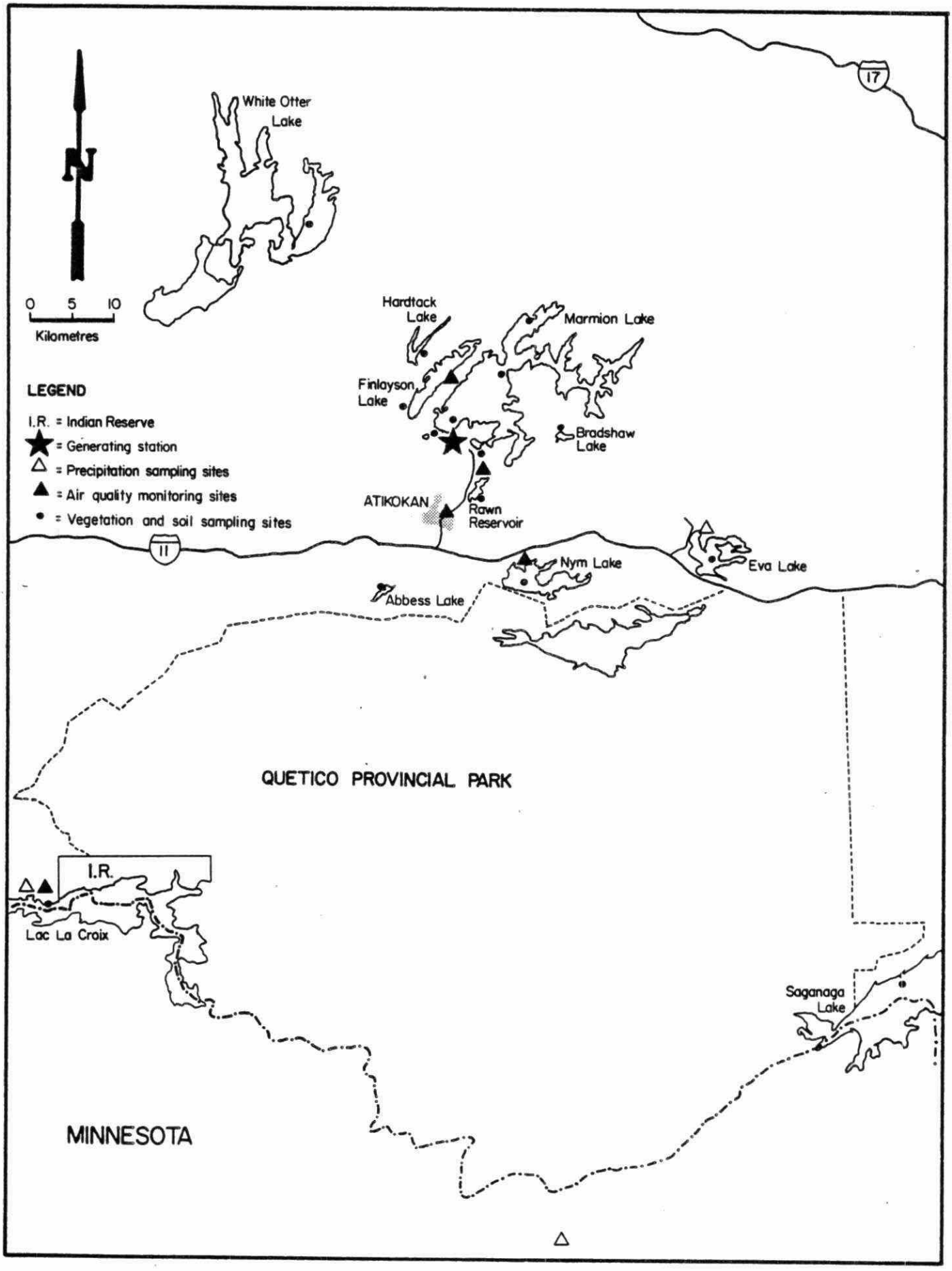

Figure 1. Air quality assessment sites, Ontario Hydro generating station, Atikokan.

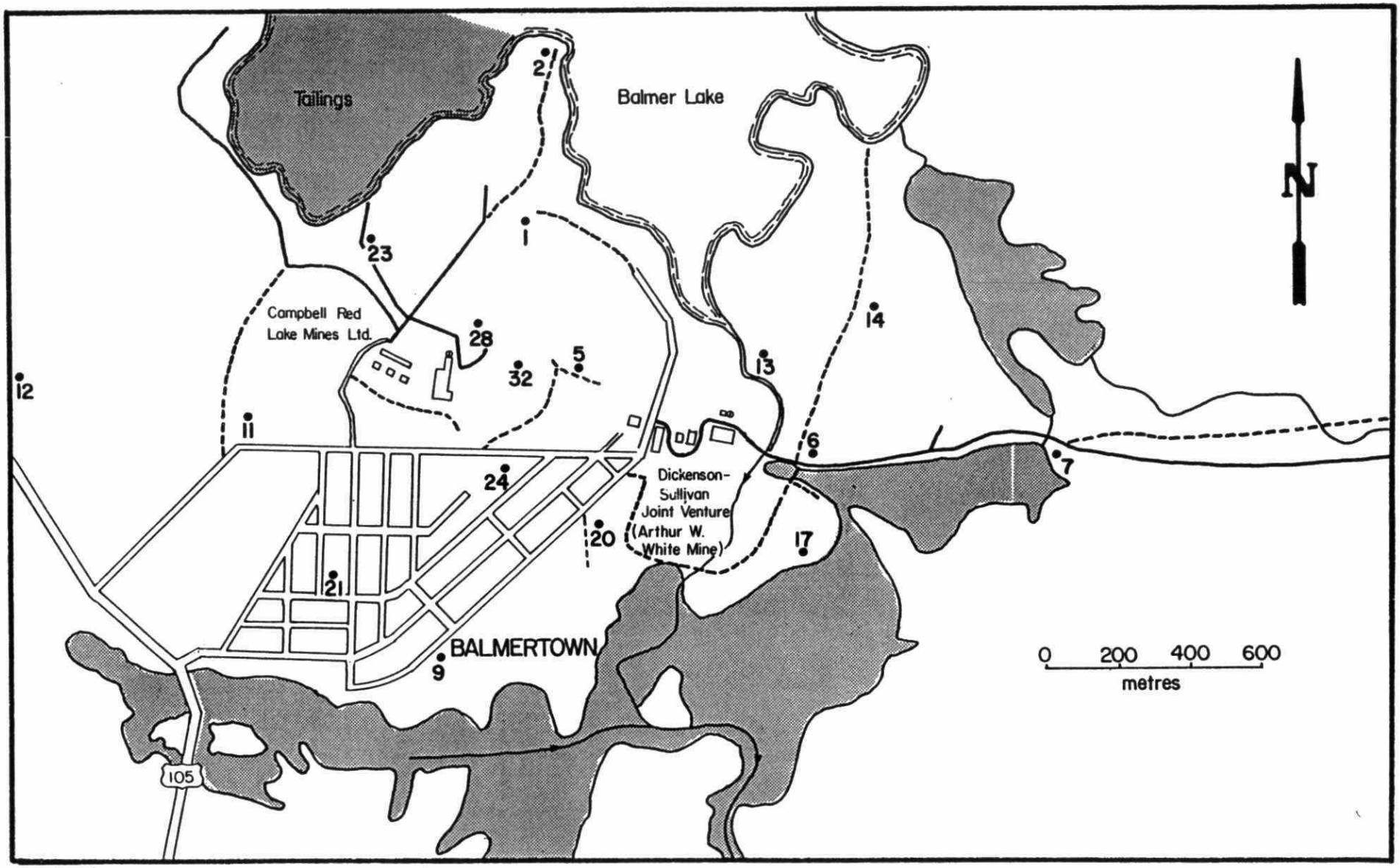

Figure 2. Trembling aspen sampling sites, Balmertown, 1984.

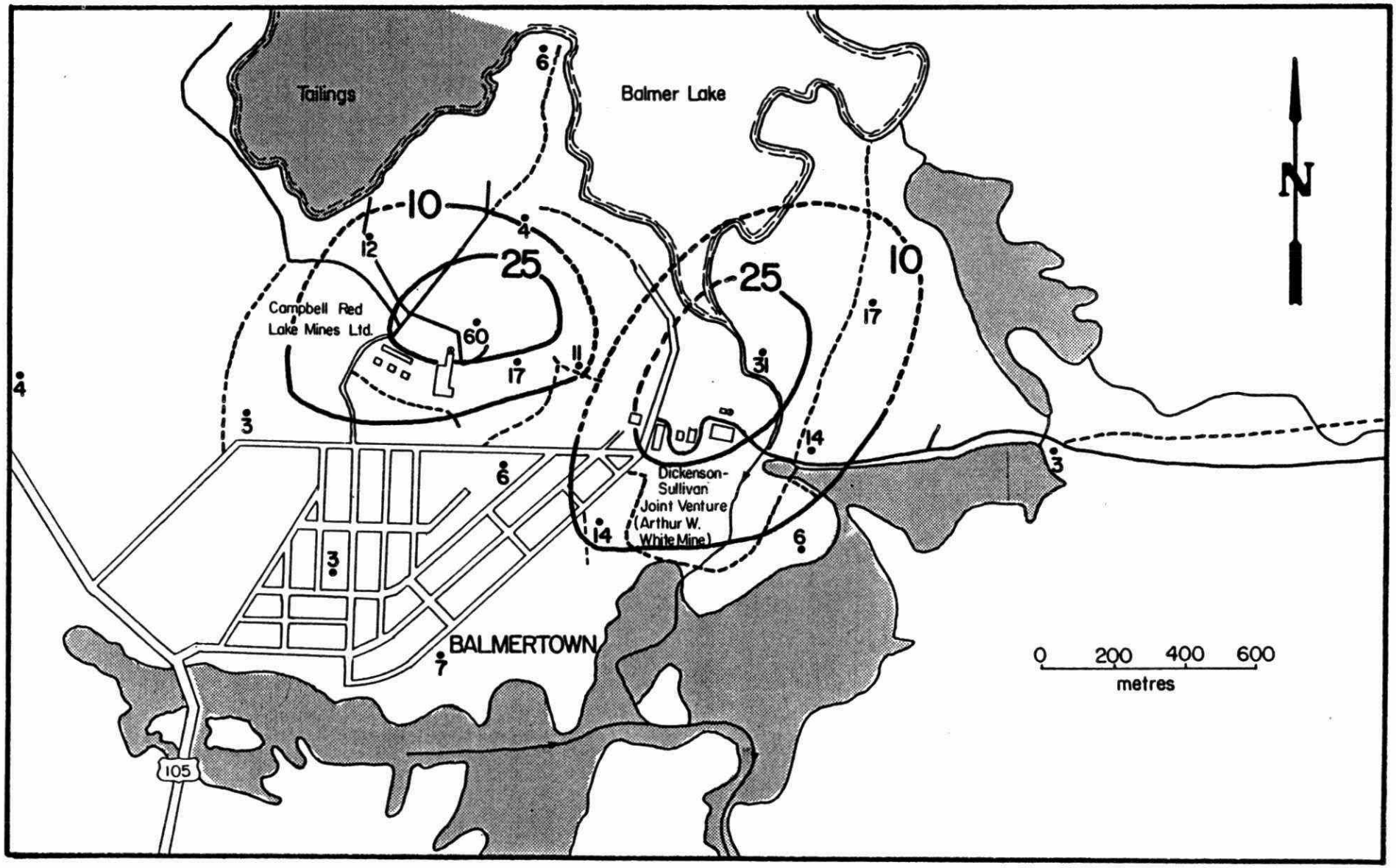

Figure 3. Arsenic (µg/g, dry weight) in trembling aspen leaves, Balmertown, August, 1984.

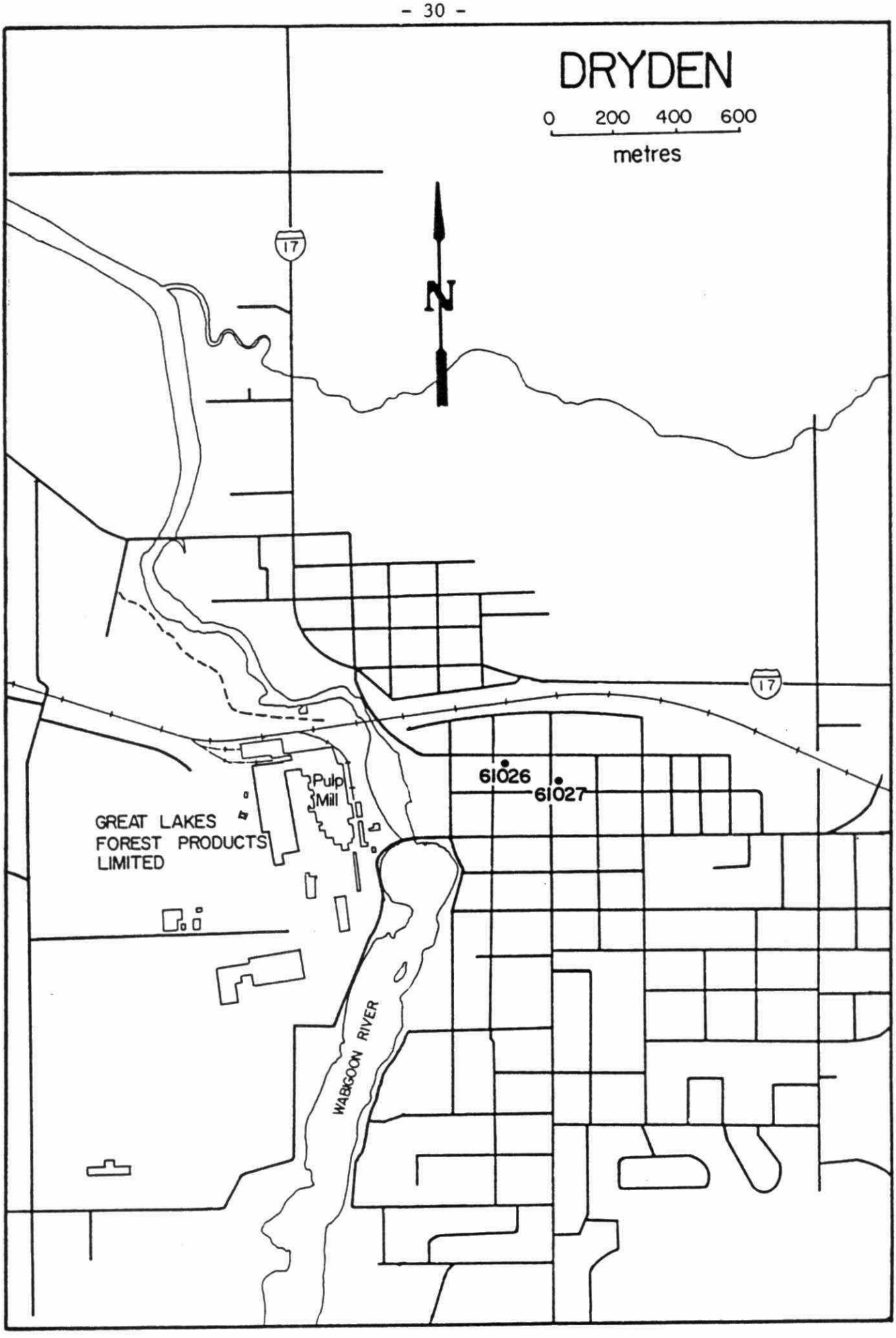

Figure 4. Air quality monitoring sites, Dryden, 1984.

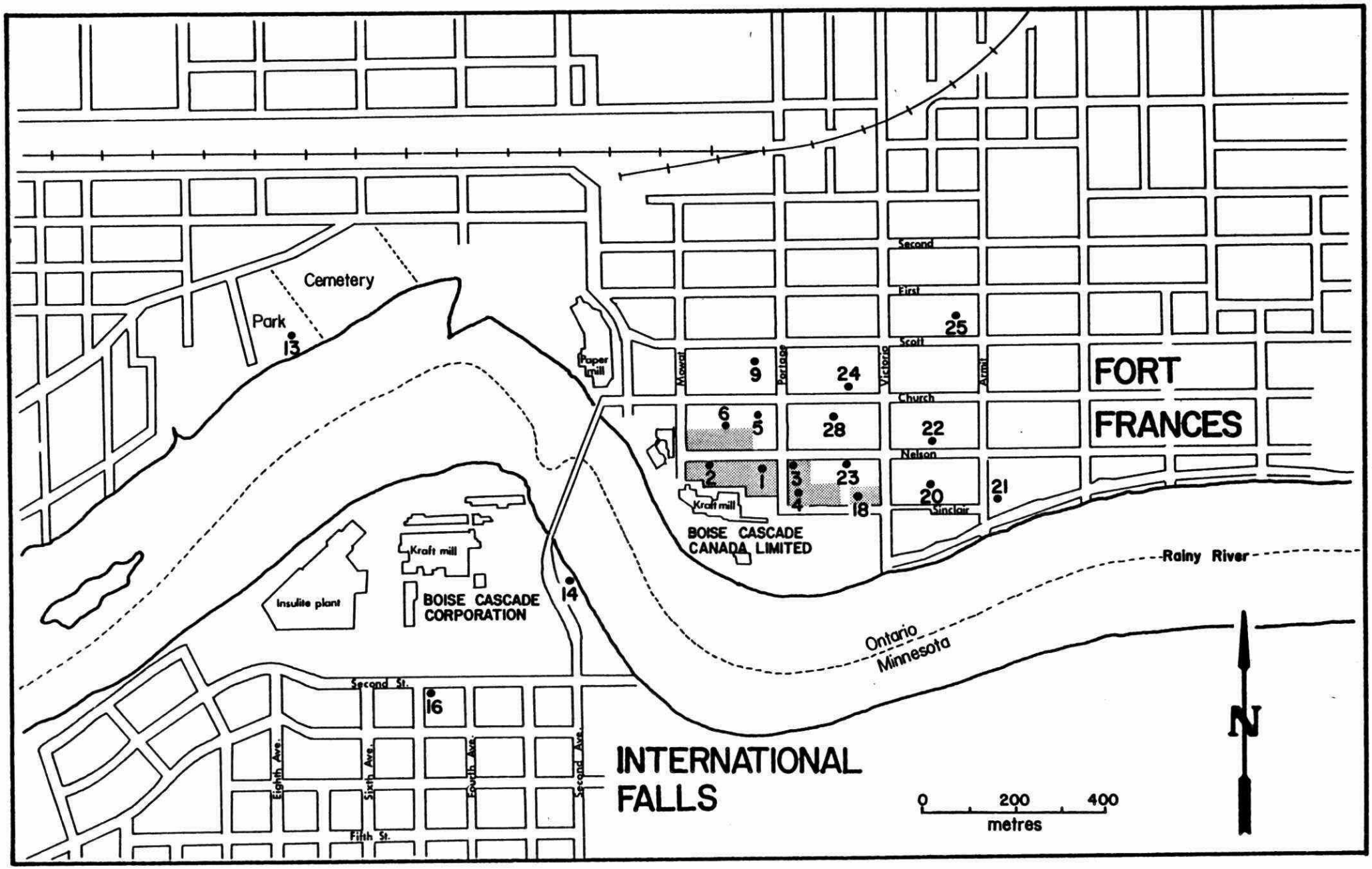

Figure 5. Manitoba maple sampling sites, Fort Frances, August, 1984. Buffer zone

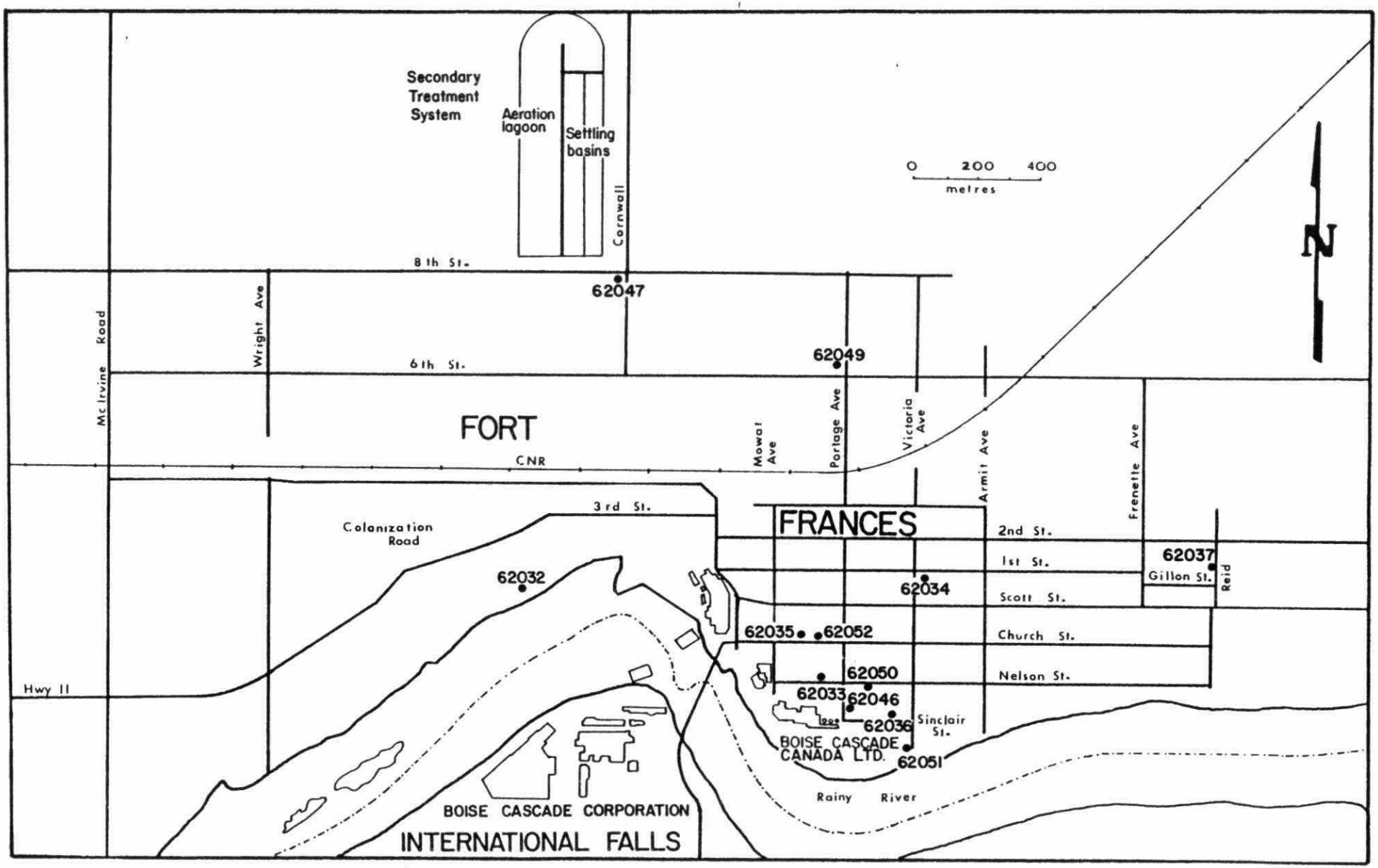

Figure 6. Air quality monitoring sites, Fort Frances, 1984.

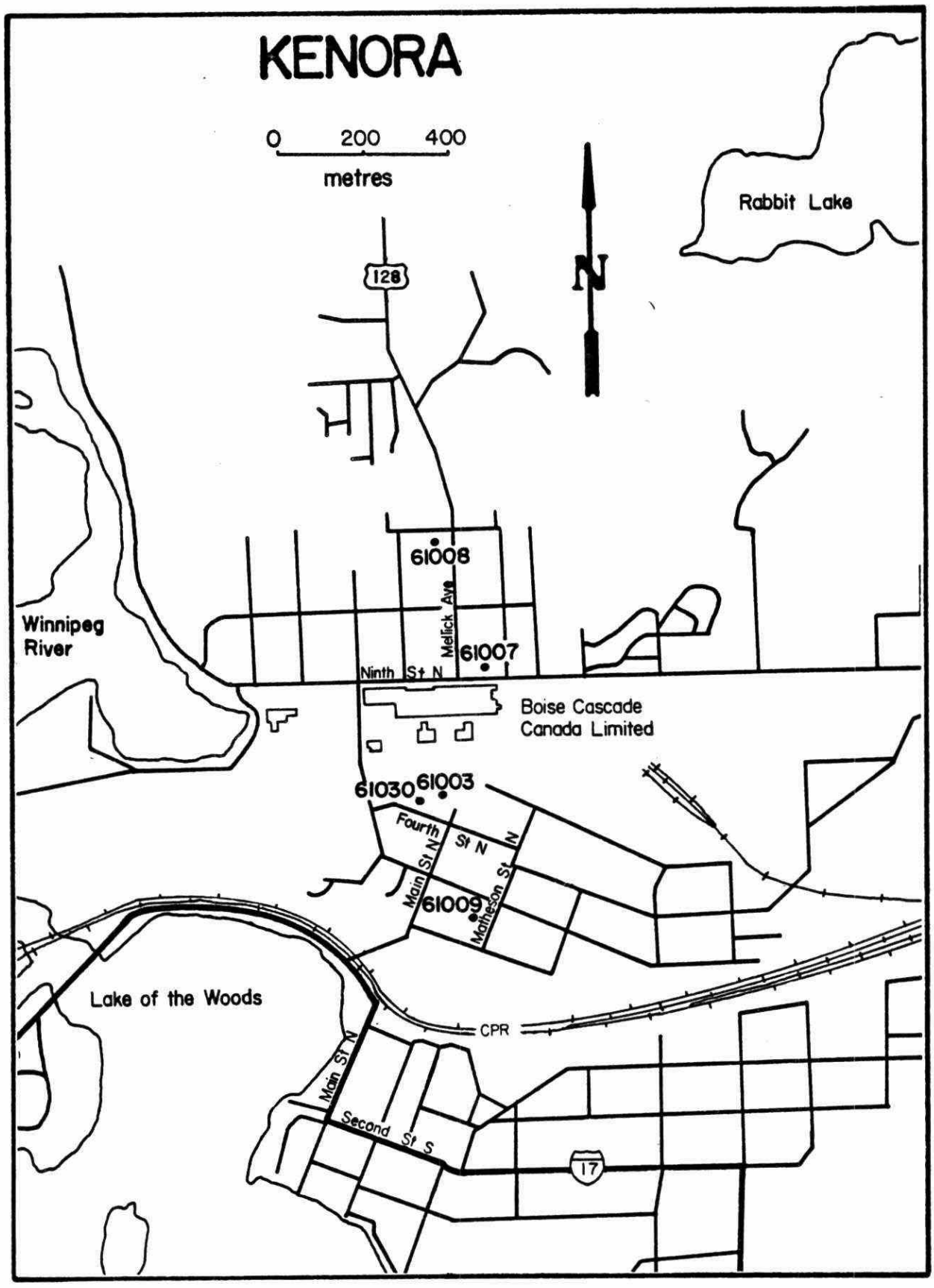

Figure 7. Air quality monitoring sites, Kenora, 1984.

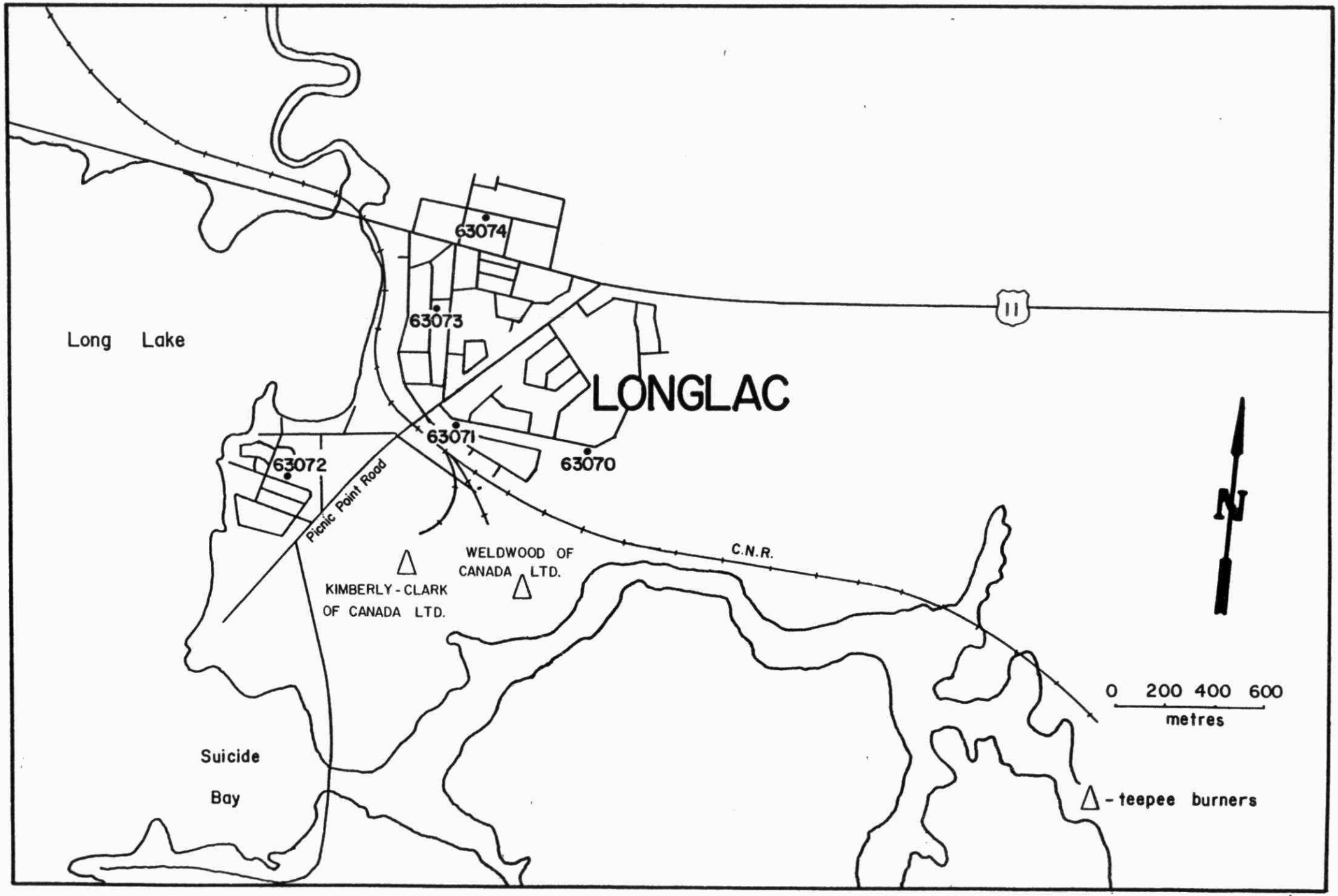

Figure 8. Air quality monitoring sites, Longlac, 1984.

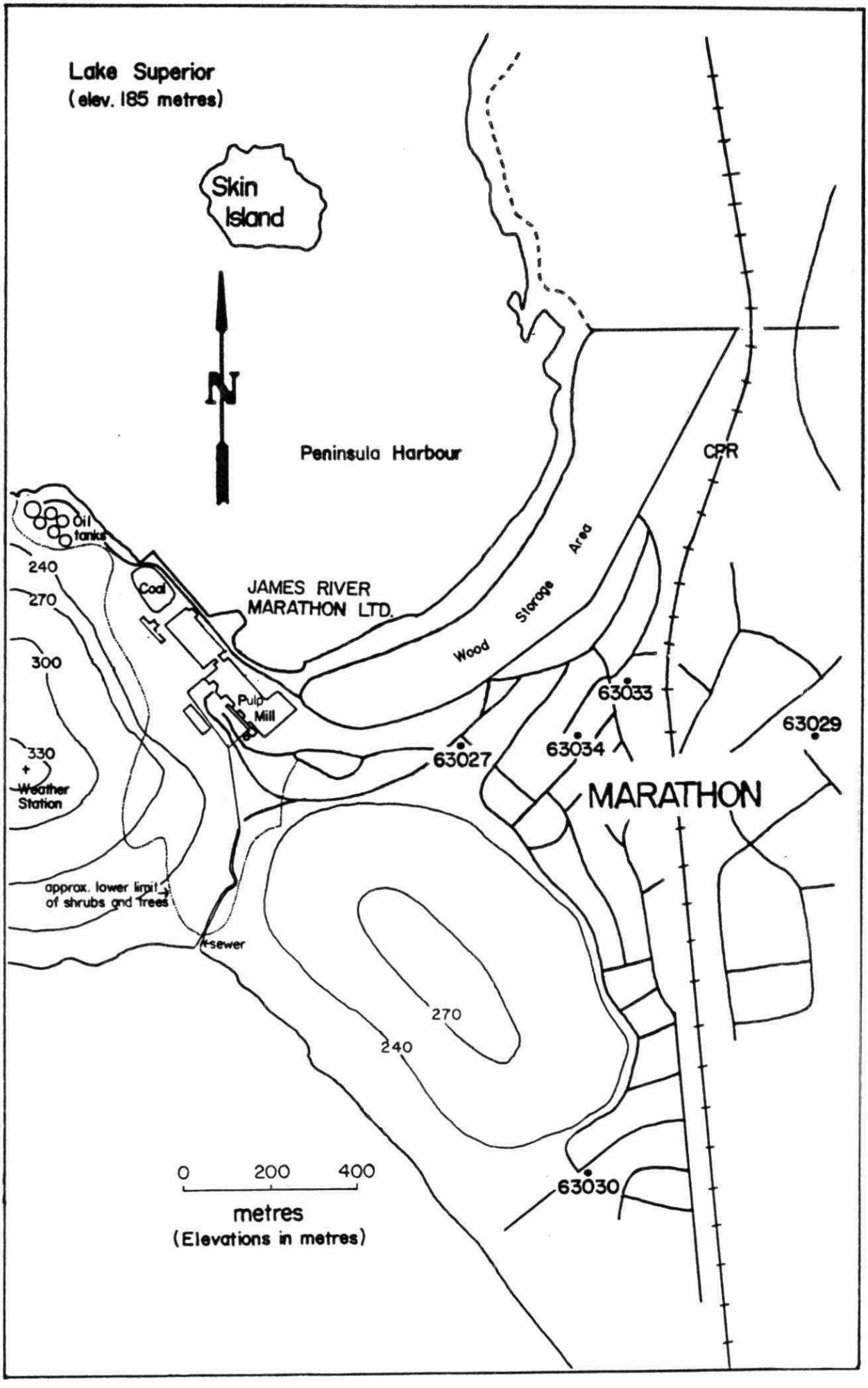

Figure 9. Air quality monitoring sites, Marathon, 1984 (except station 63032, Heron Bay).

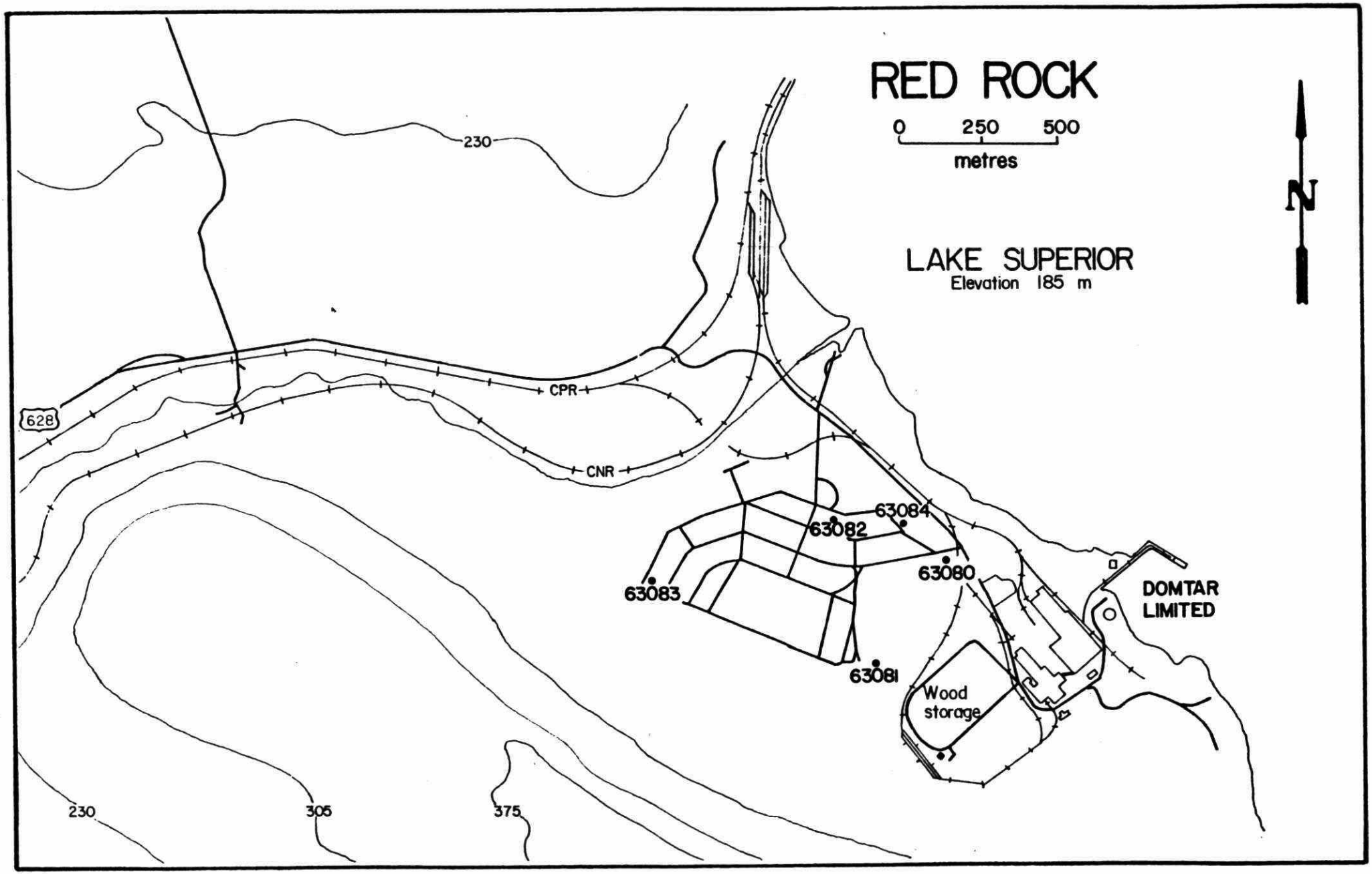

Figure 10. Air quality monitoring sites, Red Rock, 1984

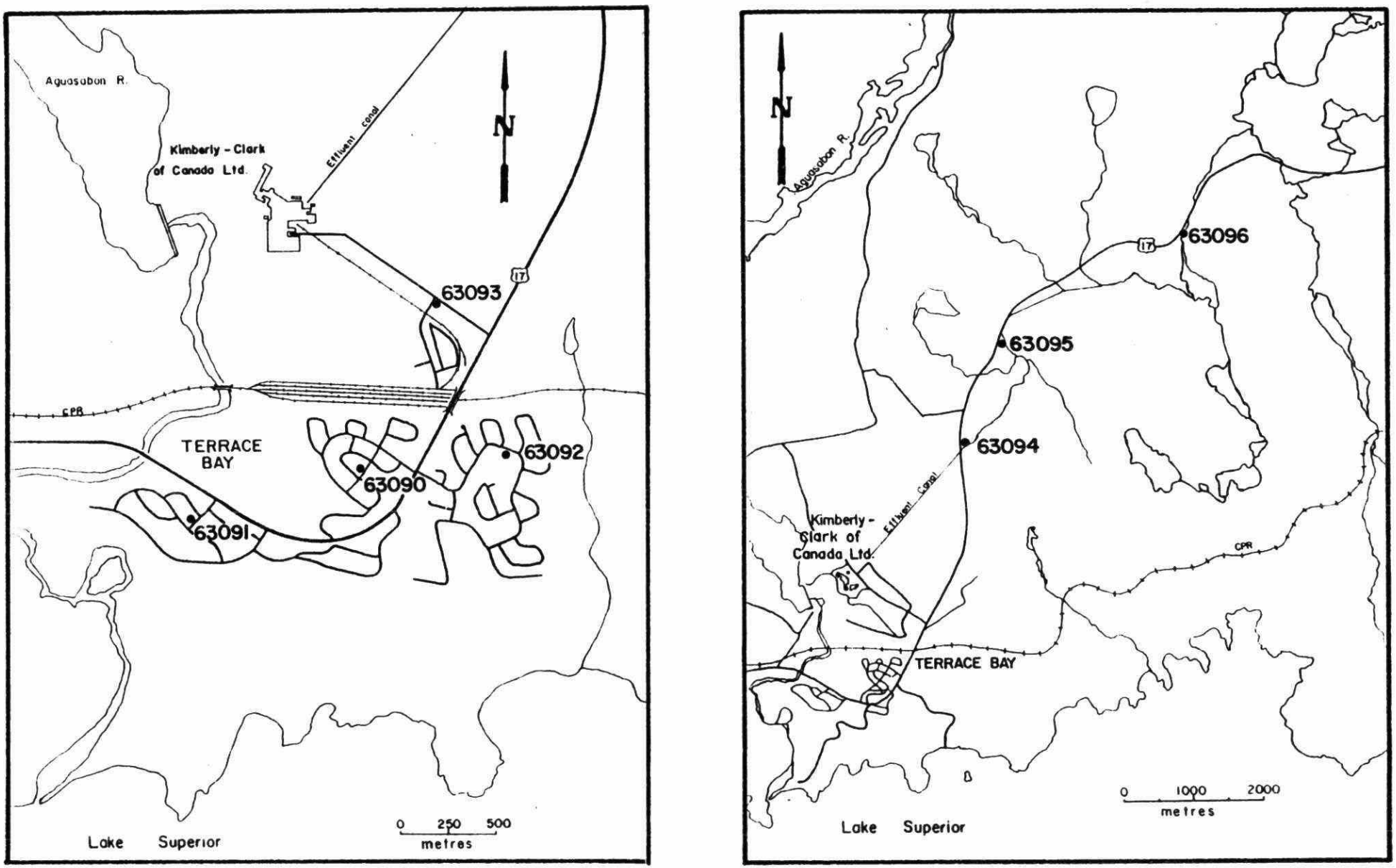

Figure 11. Air quality monitoring sites, Terrace Bay, 1984.

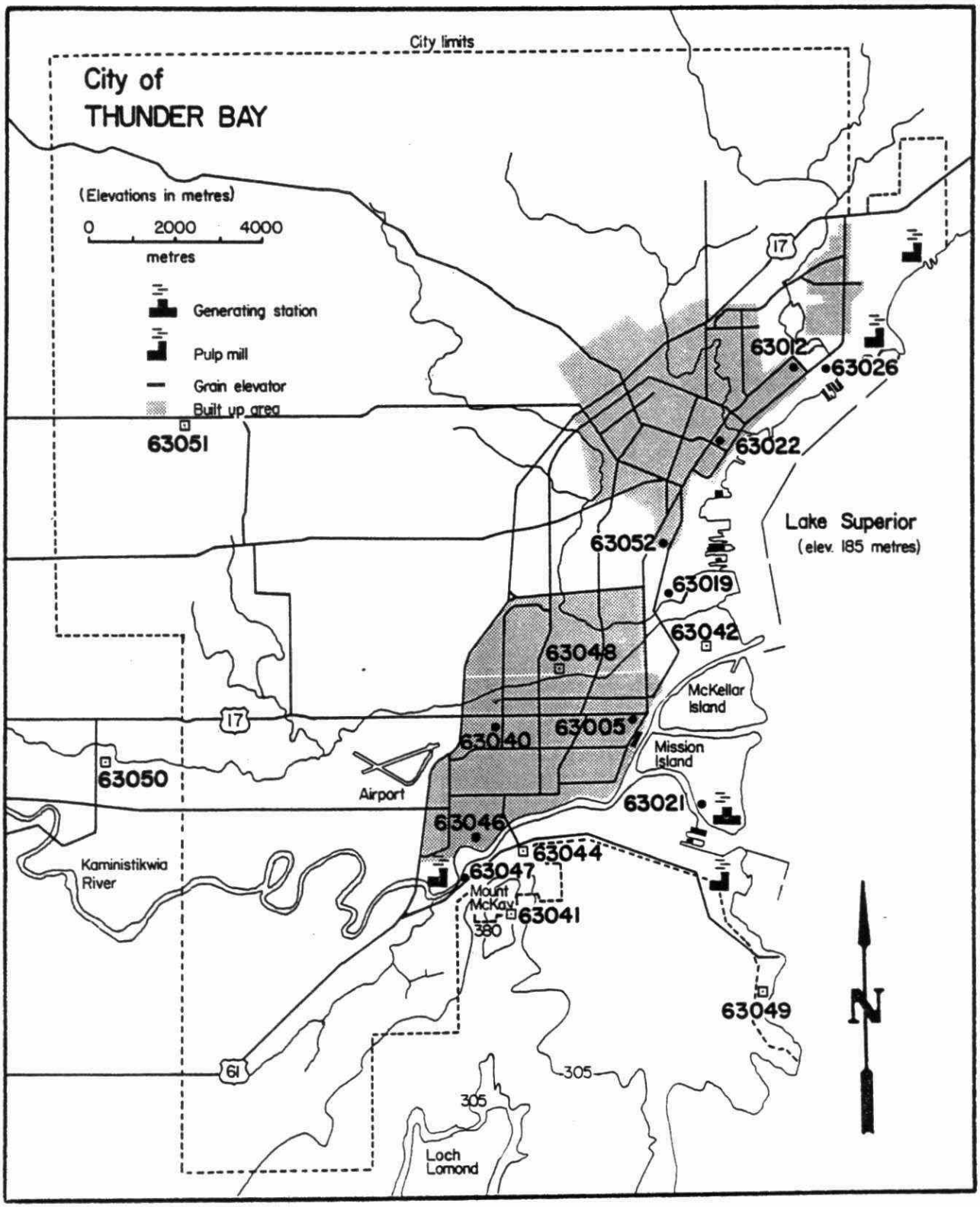

Figure 12. Air quality monitoring sites, Thunder Bay, 1984.
(⊡ Ontario Hydro sites)

TABLE 1. Arsenic content (µg/g, dry weight) of unwashed trembling aspen foliage near Balmertown, 1972 to 1984.

Site[a]	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1			26[b]	31	10	5	4	3	6	5	9	5	4
2			22	26	6	12	9	3	6	4	12	6	6
5	160	550	29	33	18	12	9	22	28	6	60	19	11
6	78	400	200	260	50	8	33	11	55	63	36	38	14
7	21	81	43	29	5	4	20	4	4	2	5	5	3
8			14	18	4	2	6	2	2	1			
9	260	410	19	6	6	5	5	9	3	5	5	4	7
11	98	110	10	7	2	4	2	5	3	4	6	4	3
12	27	41	9	9	4	3	3	6	1	2	13	2	4
Controls	<1	8	3	2	<1	<1	<1	<1	<1	<1	<1	<1	<1

[a]Shown in Figure 2.

[b]Values above proposed contaminant guideline (2 µg/g) are underlined.

TABLE 2. Average arsenic content (µg/g, dry weight)[a] of unwashed foliage from planted roadside Manitoba maple (Acer negundo) and white elm (Ulmus americana) trees, Balmertown, 1973 to 1984.

Year	Side of tree[b]	Dickenson & Mine Road	Balmertown public school	Fifth St. & Mine Road	Controls
1973	Facing	504[c]	734	352	19
	Away	323	432	202	25
1974	Facing	70	36	20	4
	Away	31	21	12	
1975	Facing	138	76	34	4
	Away	58	46	18	
1976	Facing	18	12	20	2
	Away	18	9	11	
1977	Facing	13	6	8	<1
	Away	16	5	8	
1978	Facing	5	5	5	<1
	Away	4	4	3	
1979	Facing	69		8	2
	Away	22		7	
1980	Facing	7	5	6	1
	Away	5	5	3	
1981	Facing	11	7	8	<1
	Away	12	7	5	
1982	Facing	14	8	10	<1
1983	Facing	18	7	-	<1
1984	Facing	8	4	3	<1

[a]Values for 1975 to 1979 are averages of triplicate samples. Those for other years represent single samples.

[b]Facing and away from gold mines.

[c]Values above proposed contaminant guideline (2 µg/g) are underlined.

TABLE 3. Average arsenic levels[a] (µg/g, dry weight) in washed vegetables and surface soil (0-5 cm) from three Balmertown gardens, 1973-1984.

Sample	1973	1974	1976	1978	1980	1982	1984
				Balmertown			
Potato leaves[c]		18	15	6	17	13	11
Potato tubers		2	2	<1	2	<1	<1
Beet leaves	180[d]	8	7	2	8	3	5
Beet roots	40	3	4	3	6	5	3
Lettuce leaves	140	9	12	9	36	8	20
Garden soil		160	60	120	160	100	82
Lawn soil		570	210	280	440	310	230
				Red Lake (control)			
Potato leaves[c]		4	2	1	2	2	1
Potato tubers		<1	<1	<1	<1	<1	<1
Beet leaves	3	<1	<1	<1	2	<1	<1
Beet roots	2	<1	<1	<1	<1	<1	<1
Lettuce leaves		2	<1	1	2	1	<1
Garden soil		10	8	6	7	7	8
Lawn soil		14	9	11	11	13	10

[a]Values for 1975 to 1979 are averages of triplicate samples. Those for other years represent single samples.
[b]Two gardens in 1979 and 1984. [c]Unwashed.
[d]Values above proposed contaminant guidelines (2 µg/g for vegetation, 10 µg/g for soil) are underlined.

TABLE 4. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1977-1984.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1977	325	3.7	164	270
1978	282	6.7	479	400
1979	200	8.7	236	391
1980	275	6.1	436	476
1981	279	5.5	190	405
1982	312	2.1	139	153
1983	257	1.5	121	68
1984	327	1.1	187	28

TABLE 5. Average chloride and sodium concentrations in unwashed Manitoba maple foliage, Fort Frances-International Falls, 1980-1984.

Site[a]	Chloride (%, dry weight)			Sodium (µg/g, dry weight)		
	1980	1982	1984	1980	1982	1984
1	1.20[b]	0.26	0.26	1800[b]	560	1200
2	0.81	0.30	0.21	1400	1900	970
3	0.87	0.21	0.19	1200	120	530
4	0.71	0.21	0.13	620	190	350
5	0.35	0.13	0.13	260	160	620
6	0.36	0.21	0.16	390	770	650
9	0.22	0.22	0.16	150	86	320
13	0.04	0.03	0.03	83	110	66
14	0.08	0.13	0.08	53	230	270
16	0.53	0.41	0.10	73	88	640
18	0.21	0.10	0.09	120	38	150
20	0.10	0.08	0.07	250	120	150
21	0.15	0.14	0.10	250	48	54
22	0.13	0.11	0.07	240	120	190
23	0.26	0.06	0.06	280	57	210
24	0.42	0.22	0.09	210	99	160
25	0.17	0.11	0.08	410	120	150
28		0.16	0.11		70	270
Controls	0.10	0.07	0.06	100	65	84

[a]See Figure 5 for station locations.

[b]Values above proposed contaminant guidelines (350 µg/g for sodium and 0.85 for chloride) in vegetation are underlined.

TABLE 6. Average annual dustfall (g/m²/30 d), Fort Frances, 1984.

Monitoring station	Total dustfall	Insoluble dustfall	Saltcake in dustfall
62032	4.2	2.6	0.4
62033	12.6	6.4	4.0
62034	6.7	4.0	1.0
62035	9.4	5.7	2.3
62036	14.7	9.9	2.6
62037	4.6	2.3	0.8
62046	11.4	6.1	2.7
62050	10.2	6.4	2.1
Averages	9.2	5.4	2.0
% of total dustfall		59	22

[a]Values above the maximum acceptable limit (4.6 g/m²/30 d) are underlined.

TABLE 7. Average annual dustfall (g/m²/30 d) at six Fort Frances monitoring sites[a], 1979-1984. Percentages of total dustfall are shown in parentheses.

Parameter	1979	1980	1981	1982	1983	1984
Total dustfall	8.7	7.0	7.6	7.2	7.5	9.0
Insoluble dustfall	4.0 (46)	3.9 (56)	4.4 (58)	4.0 (56)	4.1 (55)	5.2 (58)
Saltcake in dustfall	2.1 (24)	1.2 (17)	1.2 (16)	1.3 (18)	1.2 (16)	1.9 (21)

[a]Stations 62032, 62033, 62034, 62036, 62037 and 62046.

TABLE 8. Summary of total reduced sulphur concentrations (ppb) at stations 62030, 62052, 62032 and 62051, Fort Frances, 1976-1984.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
		Station 62030		
1976	309	12.8	458	916
1977	294	15.4	480	969
1978	304	16.1	540	1035
1979	344	10.2	353	911
1980	352	9.3	499	872
1981	277	12.0	279	806
1982	320	8.8	543	685
1983[a]	336	4.9	254	418
1984[a]	332	2.8	98	135
		Station 62032		
1976	139	2.5	116	91
1977	225	3.3	129	176
1978	281	2.5	134	141
1979	306	2.9	140	178
1980	307	3.3	124	210
1981	271	3.1	211	202
1982	269	2.1	99	115
1983	309	2.8	87	180
1984	314	1.9	74	38
		Station 62051		
1983	349	4.3	161	345
1984	366	5.3	284	509

[a]Station 62052.

TABLE 9. Average annual dustfall (g/m²/30 d), Kenora, 1981-1984.

Station[a]	Location	1981	1982	1983	1984
61003	Fourth/Main	4.7[b]	3.1	2.5	4.8
61007	Melick/Ninth	14.1	10.0	7.0	10.9
61008	Melick/Eleventh	4.1	2.7	2.5	3.3
61009	Third/Matheson	7.1	4.5	3.3	4.5
	Averages	7.5	5.1	3.8	5.9

[a]See Figure 7.
[b]Values exceeding maximum acceptable level of 4.6 are underlined.

TABLE 10. Average annual sulphation rates (mg SO_3/100 cm²/d), Kenora, 1981-1984.

Station	Location	1981	1982	1983	1984
61003	Fourth/Main	0.11	0.07	0.06	0.05
61007	Melick/Ninth	0.21	0.10	0.10	0.07
61008	Melick/Eleventh	0.18	0.15	0.20	0.11
61009	Third/Matheson	0.07	0.05	<0.05	<0.05
	Averages	0.14	0.09	0.10	0.06

TABLE 11. Average annual dustfall levels (g/m²/30 d), Longlac, 1984.

Station[a]	Location	Monthly range	Annual average
63070	Sewage Plant	0.9 - 11.6	5.8[b]
63071	Centennial Drive	2.5 - 11.9	7.7
63072	Poplar Street	1.2 - 17.4	6.3
63073	Dieppe Road	1.3 - 7.8	4.2
63074	Riverview Street	0.9 - 13.1	4.3

[a]See Figure 8.
[b]Averages exceeding the objectives of 7.0 (monthly) or 4.6 (annual) are underlined.

TABLE 12. Average annual sulphation rates (mg SO_3/100 cm^2/d), Marathon, 1976 to 1984.

Station	Location	1980	1982	1984
63027	McLeod/Abrams	0.12	0.18	0.16
63029	Marathon Shell	0.09	0.11	a
63030	Howe/Yawkey	0.11	0.11	0.10
63032	Heron Bay	0.06	0.08	0.04
63033	Water Tower	0.16	0.15	0.14
	Averages	0.12	0.13	0.11

[a]Insufficient data to calculate average.

TABLE 13. Summary of TRS concentrations (ppb) at station 63034, Marathon, 1983-84.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1983	310	0.9	72	25
1984	329	1.0	71	22

TABLE 14. Average annual dustfall (g/m²/30 d), Red Rock, 1980-1984.

Station[a]	1980-82			1983			1984		
	Total	Insoluble	Saltcake	Total	Insoluble	Saltcake	Total	Insoluble	Saltcake
63080	9.2[b]	4.1	2.7	5.9	3.9	1.2	9.0	5.5	1.2
63081	5.6	2.5	1.5	4.3	2.4	0.5	5.9	3.4	0.7
63082	12.6	3.1	7.2	6.0	2.4	2.1	7.0	3.8	1.0
63083	3.1	1.3	1.0	2.0	1.0	0.3	2.1	1.0	0.3
Average	7.6	2.8	3.1	4.6	2.4	1.0	6.0	3.4	0.8

[a]See Figure 10.

[b]Values exceeding annual objective of 4.6 g/m²/30 d are underlined.

TABLE 15. Average annual sulphation rates (mg SO_3/100 cm^2/d), Red Rock, 1980-1984.

Station	Location	1980	1981	1982	1983	1984
63080	Rankin Street	0.66	0.46	0.50	0.31	0.19
63081	Stewart/Frost	0.15	0.15	0.11	0.10	0.08
63082	47 Timmins Street	0.27	0.27	0.21	0.10	0.08
63083	122 Brompton Road	0.13	0.11	0.08	<0.05	0.04
	Averages	0.30	0.25	0.22	0.13	0.10

TABLE 16. Summary of TRS concentrations (ppb) at station 63084, Red Rock, 1982-84.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1982	292	5.0	339	317
1983	300	1.8	156	98
1984	365	1.3	111	23

TABLE 17. Average annual sulphation rates (mg/SO_3/100 cm^2/d), Terrace Bay, 1982-1984.

Station	Location	1982	1983	1984
63090	St. Martin School	0.15	0.14	0.08
63091	Ft. Garry Road	0.10	0.14	0.08
63092	Terrace Heights Dr.	0.10	0.07	0.06
63093	Mill Road	0.10	0.08	0.09
63094	Highway 17, #1	0.10	0.14	0.13
63095	Highway 17, #2	0.08	0.08	0.06
63096	Highway 17, #3	0.04	0.06	0.06
	Averages	0.10	0.10	0.08

TABLE 18. Summary of TRS concentrations (ppb) at station 63090, Terrace Bay, 1982-84.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1982	155	0.6	50	7
1983	333	0.9	102	30
1984	331	1.2	104	38

TABLE 19. Total dustfall ($g/m^2/30$ d) and average pH of dustfall solutions, Thunder Bay, 1984.

Station	Location	Monthly Min	Monthly Max	Annual average
63005	McKellar Hospital	1.6	5.5	3.4
63012	Dawson Court	1.4	5.6	3.1
63019	Main St. Pumping Station	1.2	13.0[a]	4.5
63021	Mission Island	0.6	3.8	2.1
63022	St. Joseph's Hospital	0.9	6.3	3.4
63026	N. Cumberland Hydro	1.3	7.1	3.9
63040	435 James St. South	0.3	5.6	2.6
63046	Montreal Street	4.2	10.8	6.3
63047	Totem Trailer Court	3.1	21.8	9.4
63052	Thunder Bay Transit	1.1	10.5	4.3

[a]Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 20. Total dustfall (g/m²/30 d) at Totem Trailer Court (station 63047), during winter months from 1978 to 1985.

Year	Nov	Dec	Jan	Feb	Mar	Mean
1978-79	1.5	1.5	2.8	0.1	3.0	1.8
1979-80	6.7	1.8	2.7	4.8	5.2	4.2
1980-81	3.0	2.9	1.8	5.2	4.9	3.6
1981-82	10.1[a]	12.7	8.7	9.8	12.6	10.8
1982-83	17.5	15.1	16.6	16.0	9.8	15.0
1983-84	9.1	6.5	9.9	3.1	6.9	7.1
1984-85	8.8	6.4	3.4	5.2	8.9	6.5

[a]Values exceeding maximum acceptable level of 7.0 are underlined.

TABLE 21. Total suspended particulate matter (µg/m³), Thunder Bay, 1984.

Station	Number of samples	Annual geometric mean	Number of samples above 120 µg/m³	Maximum 24-hour value
63005	57	44	4	175
63012	54	33	1	156
63022	56	36	nil	111
63040	53	32	nil	97
63046	34	b	1	188
63052	56	54	9	179

[a]Values exceeding the maximum acceptable limit of 120 µg/m³ (24-hour average) or 60 µg/m³ (annual geometric mean) are underlined.
[b]Insufficient number of samples to calculate annual mean.

TABLE 22. Summary of sulphur dioxide concentrations (ppm) in Thunder Bay, 1984[a].

Station	Location	Annual average	Maximum 1-hour average	Maximum 24-hour average
63022	St. Joseph's Hospital	<0.001	0.02	<0.01
63040	435 S. James Street	<0.001	0.04	<0.01
63041[b]	Mt. McKay	0.004	0.37	0.03
63042[b]	East End	0.003	0.04	0.02
63044[b]	James St./Kam River	0.004	0.10	0.02
63048[b]	Ford Street	0.002	0.05	<0.01
63049[b]	Chippewa Park	0.002	0.05	0.01
63050[b]	Paipoonge	0.001	0.04	<0.01
63051[b]	John Street Landfill	0.001	0.04	<0.01

[a]12 months of data for all stations except for 63041 (11 months), 63042 (10 months), and station 63048 (10 months).

[b]Ontario Hydro. 1984-85. Environmental Quality Compliance Reports, 1984. Technical Training Services Division.

TABLE 23. Summary of total reduced sulphur concentrations (ppb), staton 63046, Thunder Bay, 1977-1984.

Year	Days of data	Annual average	Maximum 1-hour average	Number of times above guideline
1977	298	1.5	56	17
1978	280	1.9	48	28
1979	218	2.6	58	26
1980	220	2.9	131	90
1981	340	2.8	72	74
1982	299	1.0	36	7
1983	305	0.5	36	3
1984	164	0.6	22	nil